University of Vermont

Burlington, Vermont

PROGRESS REPORT NO. 1

October 30, 1965

to

National Aeronautics and Space Administration

Grant NRG 46-001-008

Dr. Clinton D. Cook, Dean of Faculties

Director of Space Science Program

UNIVERSITY OF VERMONT
Burlington, Vermont

REPORT NO. 1 - OCTOBER 30, 1965

NASA GRANT NRG 46-001-008

Although this grant was activated during the middle of the spring semester the grant already has had a significant impact on research activity at the University of Vermont. To date, practically all of the funds have been allocated and twelve research projects are under way. The areas of research, although space science oriented, cover a broad spectrum including physics, chemistry, zoology, botany, engineering and medicine. Several are interdisciplinary. The interdisciplinary projects include one with co-investigators from the departments of electrical engineering and physiology studying electrical currents in the human brain; another, a combination of electrical engineers, radiologists and surgeons working on a novel display system using color television which, it is hoped, will make it possible to extract more information from radiographs.

Our institution being relatively small and having a compact campus with all of the major facilities encompassed in a radius of no more than 300 yards made us peculiarly fitted for the evolution of interdisciplinary activity. Nevertheless, this possibility did not come to fruition until the receipt of the NASA general support grant. By providing tangible evidence for the support of such a program and the means for implementing it, a veritable avalanche of activity has been generated. The enthusiasm and vigor the interdisciplinary programs are showing is tremendously exciting and augurs very well for the future of our institution. As an example of the type of spirit which has been engendered it is worth pointing out that at their own initiative the medical school faculty are this semester giving a course in human biology for the education of their colleagues in the non-medical fields and some 30 to 35 engineers and scientists from all over the campus are attending. Next semester the engineers and scientists propose to give a program on instrumentation for the medical school personnel.

The existence of the broad interdisciplinary program has encouraged many discussions between various campus groups and has been a potent device for encouraging staff members to recognize possible interactions of their own work with that of colleagues in widely separated disciplines. As a result, viable interdisciplinary programs are springing up all over the campus. The initial success in these cooperative ventures has encouraged many faculty to bring to fruition long-standing dreams of cooperative endeavor and mutual respect and cooperation have been encouraged. The long-term effect is that the attack on all research at the University of Vermont can

be from a new and enlightened point of view as opposed to the classical approach restricted by the harsh compartmentalization of disciplines or academic departments.

The flexibility of the NASA grant makes it possible to provide immediate support for new investigators thereby increasing the efficiency of utilization of new personnel. It also makes it possible to give immediate support for a new research idea almost as soon as it is born and while the investigator's enthusiasm is at a peak. This is in sharp contrast with the usual type of project type support from an outside agency where the relatively long delay between the conception of an idea and the receipt of support is discouraging to the investigator in many cases. A most important facet of the institutional type of support is that the administration of the University has an opportunity to provide guidance in the direction of its research program and to maintain balance and coherence. Furthermore, occasionally a research project will reach a 'deadend' at an early stage but the flexibility achieved by the institutional type of support makes it possible to immediately shift emphasis and deploy the funds to greater advantage.

Although the expertise to carry out significant research existed at the University of Vermont, the funds derived from NASA have spurred the research effort and have helped to provide better balance between research and teaching. At the graduate level, research and education are inseparable and the effects of the grant have been obvious. A significant improvement in undergraduate education has been observed also. In engineering specifically and at all levels, the increased research activity affects education by providing 'real life' problems and examples as opposed to the hypothetical, academic, textbook type frequently used in institutions where research is not so prevalent.

In the following pages will be found brief progress reports submitted by each of the principal investigators receiving support from this grant. While most of the reports are self-explanatory, particularly when coupled with the project proposals which will be found in the appendix, some comments on certain of the projects may be helpful.

In the past the University has had inadequate shop facilities. Most of the departments active in research have had small shops equipped with only the most essential tools. When the new engineering building was built in 1963, the first step was taken to provide better shop facilities by combining the shops of the three engineering departments and providing some additional equipment. Certain other tools were needed, however, and Project I was set up to provide funds for augmenting the shop facilities. As will be noted from the progress report of Mr. Marshall, this support has made it possible to provide better service for some of the investigators. It will be of interest to note here that plans are now ...

under way to establish, probably by the end of this fiscal year, an all-university shop for the support of research. It is hoped that some funds from the sustaining grant can be applied to this development.

In Project VI, Dr. Lai, a new member of the Electrical Engineering Department staff and an expert in information theory, has been working very closely with Dr. Couch. The work being conducted by Dr. Couch and Dr. Lai, in addition to having direct application to the man in space program of NASA, has a very important potential benefit to the health sciences and in this case a potential application to mankind in general. The work is of special interest to a number of members of the Medical College staff and is one of the most significant medical applications of the digital computer at the University of Vermont.

In connection with Project X, it should be emphasized that the equipment purchased for Dr. Hyde in Botany will be useful to many other research projects requiring the same technique for preparing specimens for electron microscopy.

Dr. Wilfred Roth and his colleagues who are working with him on Project VII report on a unique scheme to enable radiologists to analyze more accurately the common radiograph. By displaying a radiograph on a television color screen in such a way that different density levels are shown in different colors, subtle differences in density are more obvious and shadows which might normally be overlooked should be more apparent. The unusual situation of the engineering group on the same campus and in close proximity to the medical school has encouraged this type of research and will simplify clinical testing of the scheme.

PROJECT 1 - UNIFIED ENGINEERING SHOP

Supervisor: G. A. Marshall, Associate Professor of Mechanical Engineering

Amount of Grant: $6,025

Progress Report - October 8, 1965

Increasing demands have been made on shop facilities for precision work, primarily for research activities, and additional equipment was desperately needed to meet these demands. Our new tool room lathe enables us to maintain tolerances in the range of .0005 to .001 inches with ease. The engraving machine is capable of cutting any shallow form or contour for which we have, or can make, a master. Until now we have had no facility for duplicating any form. The die filing machine and belt sander enable us to do accurate finishing which in the past had to be done by hand.

We have done work on research projects from many departments including electrical and mechanical engineering, zoology, animal and dairy science, forestry, home economics, and several medical college projects. We still have to turn away some projects because we do not have the precision equipment required.

PROJECT II: EXPERIMENTAL STUDY OF PHOTOELECTRIC, OPTICAL AND SURFACE PROPERTIES OF TRANSITION METALS.

Investigators: D. W. Juenker and A. D. Crowell, Physics Department

Amount of Grant: $ 24,456

Progress Report - 30 September 1965.

Introduction

The research conducted with the support of this grant fell into two categories: (1) the initiation of a long range investigation of the photoelectric and optical properties of transition metals under the direction of Dr. D. W. Juenker and (2) the continuation of the study of the interaction of these metals with gas molecules.

Study of Photoelectric and Optical Properties

Since equipment funds were not available until the latter part of April, 1965, the assembly of experimental apparatus has been delayed. That part of the task is nearing completion at this writing, and data-taking should commence during the coming month. The time since February 1 has been occupied not only with detailed planning of experiments and assembly of available components, but also in theoretical analysis of data accumulated by the principal investigator and his students in 1964 at the University of Notre Dame. NASA has been duly credited for the partial support of this work, which has been submitted for publication in two papers. They are abstracted as follows:

Hot Electron Range in Thin Metal Films, by M. J. Brienza and D. W. Juenker (submitted to the Journal of Applied Physics, August 27, 1965).

Some general aspects of hot electron transport and emission in thin films are treated in a calculation using classically exact optical considerations. It is shown that, for films deposited on transparent substrates, the ratio of photoemission currents for illumination from front and rear can be used to determine the hot electron range without the usual approximations regarding uniformity of the work function and brevity of the optical attenuation length. The dependence of the emission ratio on film thickness is indifferent to the alternate interpretation of the range as a ballistic path length or as a diffusion length. The method of data analysis suggested by the calculation is applied to measurements in vapor-deposited unannealed films of molybdenum, tantalum, and rhenium. In all three cases, the electron ranges were less than the optical decay lengths for excitation wavelengths in the quartz ultraviolet. For molybdenum and rhenium, the ranges were 1 or 2 mμ, and for tantalum 3 to 14 mμ, the latter value occurring at the longest experimental wavelength, 265mμ. Absence of a vectorial effect in the photoemission from such films is taken as evidence that the short ranges observed should be interpreted as diffusion lengths.

Variability of the Optical Properties of Molybdenum, by C. T. Raymo and D. W. Juenker (submitted to the Journal of the Optical Society of America, September 7, 1965).

A variety of bulk and film samples of molybdenum were studied in the visible and near uv regions with the purpose of discovering regularities in the behavior of their optical constants. It was found that the dependence of the refractive indices on thickness for films thinner than 50mμ was of the type usually associated with an agglomerate state, despite the fact that no islands were observable by electron microscopy. For the case of bulk molybdenum and thicker films, the optical constants were found generally to occupy positions in a narrow band on the n-k plane, with the more completely annealed, coarse-grained materials having the higher values of n and k. Such bands extended between the approximate limits 1.0 +1.2 i and 3.6 -3.8 i for visible wavelengths: in the ultraviolet, the upper extremity moved to lower values of n with decreasing wavelength. The observed regularity in variation of the complex refractive index from sample to sample was found to be attributable to the variation in amplitude of resonant absorptions near 2.2 and 4.0 ev. The latter variation appears to be related to the degree of perfection of the sample's crystalline state.

Study of Surface Properties

Work continued on the following three problems: 1) the study of the change in electrical resistance of thin molybdenum films due to interaction with carbon monoxide; 2) the study of the change in the photoelectric work function of bulk molybdenum due to interaction with carbon monoxide; and 3) the construction of an apparatus to study the amounts of carbon monoxide adsorbed on small metal surfaces (area one square centimeter) including single crystals.

A preliminary study of the effects of carbon monoxide on the electrical resistance of molybdenum films was completed during the spring of 1965 by Mr. T. Ansbacher as the basis for an M. S. thesis. Mr. Ansbacher is a NASA pre-doctoral trainee and copies of his thesis have been sent to NASA. While these first investigations confirmed the existence of a measurable effect, and qualitative conclusions could be drawn, quantitative interpretations were not possible because the apparatus permitted him to determine neither the weight and thickness of the film nor the number of gas molecules interacting with it. A more elaborate apparatus has been designed, and construction has started, which will permit him to overcome these deficiencies.

The work on the effects of carbon monoxide on the photoelectric work function of bulk molybdenum are being carried out by Mr. J. D. Clewley, whose summer salary was paid by this grant. Mr. Clewley has been able to establish reproducible clean surface work functions for a specimen of sheet molybdenum subjected to argon ion bombardment and heating by electron bombardment. The change in the values of work function with time has been determined in the presence of a background ambient of about 10^{-9} torr and in the present of carbon monoxide at pressures in the 10^{-8} torr to 10^{-7} torr range. An M. S. thesis based on this work is in preparation.

A new system designed to permit the measurement of the number of molecules of carbon monoxide on a square centimeter metal surface has been partially constructed and tested. The technique uses a radiotagged gas and requires a thin mica window in the vacuum system for assay. The entire apparatus, including a molybdenum sample, has been assembled except for the mica window. Pressures less than 10^{-9} torr have been obtained and the electron bombardment system for outgassing the specimen has been tested. After a few modifications in design suggested by these tests, the system will be ready for actual investigations.

Project III-Numerical Method for Determining the Residual Stresses Resulting from Sudden Heating of the Inner Surface of a Short Hollow Cylinder.

Investigator: Howard Duchacek., Accociate Professor of Mechanical Engineering

Amount of Grant: $11,813

Progress Report - October 8, 1965

Research on the above project began in May of 1965 with the assignment of Professor Howard Duchacek to the project for one-quarter of his academic program for the months of April and May. During the summer of 1965, graduate students Timothy L. Brosseau and Robert B. Lee joined the project for 13 weeks of the summer and were supervised by Professor Duchacek at one-quarter of one-ninth basis. Beginning Sept. 1 of 1965 the graduate students are on a half-academic time basis supervised by Professor Duchacek on one-quarter academic basis joined by Professor Erling Chamberlain also on a quarter time basis.

During this time this group has been active with a literature search, with a numerical program designed to verify the effect of variation of thermal properties on heat transfer in metals, and with a series of heat transfer experiments designed to determine the film coefficient of a plasma jet using nitrogen plasma to transfer heat to a copper ring. Also the group has been concerned with the application of a two dimensional elastic-plastic stress analysis to a computer that should enable calculations of thermal shock stresses and residual stresses in short cylindrical rings.

At the present time, the literature search has been 70% completed. A one-dimensional study of the variation of thermal properties with temperature is approximately 50% completed at this time. Programming of a method for determination of stress analysis of the elastic-plastic condition in a cylindrical ring is approximately 20% completed. The experimental work concerned with determination of a heat transfer coefficient for the nitrogen plasma has been 60% completed. Reduction and analysis of the results of this experimentation still remains to be accomplished which will require approximately two man months.

Work forecasted will entail a completion of the above portion of the project, and utilization of the above portion of the program on the fifth and sixth portions of the project which are yet to be started. The fifth part of the program will entail

application of the computer program to determine the stress-strain conditions in a cylindrical ring at several time instants after initiation of a heat transfer rate through the inner surface. The sixth portion entails an experimental program of thermal shock of tungsten rings. An attempt will be made to correlate the computer information with the parallel experimental program to be carried on using the nitrogen plasma to heat the inner surface of the ring.

It would appear that February of 1967 is a realistic completion date for the above work.

PROJECT IV - INDIVIDUAL DIFFERENCES IN THE INFLUENCE OF SENSORY ISOLATION UPON INTELLECTUAL, EMOTIONAL, AND PHYSIOLOGICAL FUNCTIONING.

Investigator: Donald G. Forgays, Professor and Chairman, Department of Psychology

Amount of Grant: $ 15,422

Progress Report - September 9, 1965

Since initiation of this grant around the beginning of March of this year, the following progress has been made:

1. A rather complete review of the pertinent literature has been accomplished. Approximately 200 articles have been assembled, read, and abstracted. It is contemplated that a review article of this literature will be prepared in the near future.

2. On the basis of this review of literature, it was decided to employ a water-tank isolation rather than isolation in a sound-proofed chamber. This isolation is apparently far more effective in producing results quickly (within three hours or so) without the cumbersome difficulties of maintaining subjects for longer (a week) periods of time in the sound-proof room.

3. A water tank has been provided commercially and is now assembled in the space assigned to this project in the old plumbing shop.

4. The physiological measures to be obtained have been decided upon and appropriate equipment purchased (a physiograph) to make the measures.

5. The personality measures to be obtained have been decided upon and appropriate measuring instruments ordered.

6. Approximately 30 subjects have been recruited to date. It has not been difficult to obtain such "volunteers", especially in light of the subject honorarium.

7. Appropriate immersion equipment has been recently obtained, including complete face mask, compression tank, etc.

8. We are in process of evaluating the immersion equipment, employing the experimenters as subjects. After this is accomplished, an evaluation will begin of the problems involved in obtaining the various physiological measures under water. When it is determined that such measures can be obtained reliably, the first subjects will be subjected to the isolation immersion. This should occur by the middle of October. Testing will then continue throughout the duration of the grant.

PROJECT V - SMOOTH MUSCLE ACTIVITY as RECORDED BY RADIO TELEMETRY

Investigator: Kenneth R. Simmons, Assistant Professor, Animal and Dairy Science

Amount of Grant: $3,910

Progress Report - October 8, 1965

This project has not yet reached the data collecting stage principally because it was not activated until June 1, 1965. However, all of the necessary equipment has been received and some preliminary steps have been taken toward developing techniques for recording smooth muscle activity by radio telemetry. Work now in progress is concerned with comparisons between direct recording of muscle potential and that recorded via radio transmition; and with the development of sensory electrodes and their proper placement. These steps are necessary for an understanding of the signals received by the transmitter which was designed initially for ECG transmission.

PROJECT VI: DISTRIBUTION AND PHYSIOLOGICAL EFFECTS IN BRAIN OF CURRENTS FROM EXTERNAL ELECTRODES.

Investigators: Stanley Rush, Associate Professor of Electrical Engineering and Wilbert F. Chambers, Associate Professor of Anatomy.

Amount of Grant: $ 17,650

Progress Report - 30 August 1965

Progress to date has been made in four categories.

(1.) Planning
(2.) Purchase and Construction of Test Equipment
(3.) Measurement
(4.) Theoretical Analyses

Briefly, progress in each of these areas is summarized below;

(1.) Planning has been completed to cover in detail experiments and analyses which will run through approximately to June 1, 1966. Preliminary planning has been started for a following year. The initial experiments will cover studies of variation of skull thickness and resistivity, measurements of current distribution through human and cat skulls. Theoretical Analyses will be made treating the skull as sphere and as a prolate spheroid between two conduction layers. The planning phase has resulted in the specification and purchase of the equipment described below.

(2.) Equipment which has been ordered includes a signal generator, stereotaxic mounts, skulls, a preamplifier, tuned amplifier and digital voltmeter. All but the last item is at hand and that is expected within the next week. Numerous other mechanical and electrical components necessary for the current density measurements have been designed and fabricated and are being tested.

(3.) Measurements of the skulls' thickness have been carried out and measurements of skull resistivity have been initiated. The resistivity measurements were hampered by a completely unexpected effect which has been traced to fungus growth in the skull. Resolution of this difficulty is in process.

(4.) Both theoretical analyses discussed in the planning section have been initiated and carried forward to the point where it can be demonstrated that theoretical solutions are possible in a useful form.

Project VII - (a) Bioenergy Electrical Sources (b) Radiological Data Processing- Contract Demarcation and Multicolor Presentation

Investigator: Wilfred Roth, Professor and Chairman, Dept. of Electrical Engineering

Amount of Grant: $19,871

Progress Report - September 24, 1965

1. Introduction

The original award of NASA funds made in the Spring of 1965 under this project number were to be used for the development of Bioenergy Electrical Sources. Since the funds were received in mid-semester, it was not possible to appoint graduate students, acquire apparatus, etc. at the date initially anticipated. Consequently, the rate of expenditure was less than contemplated.

In view of the surplus funds, a proposal was submitted to the NASA Advisory Committee suggesting the use of part of these funds to investigate the possibility of displaying X-ray radiographs in full color. This proposal was reviewed favorably and both projects have been pursued during the summer and to the present date.

II. Progress on Bioenergy Electrical Sources.

A mechanical pressure source has been constructed to simulate the human respiratory cycle. The source can be used with either liquids or gases, but, for the present, air has been the working medium. Pneumatic elements have been fabricated to convert the cyclic pressure output of the lung simulator to a static pressure. Several hydrodynamic flip-flops have been procured to convert the static pressure head into an oscillatory pressure wave in the frequency range around one thousand cps. A piezoelectric transducer has been constructed to convert the 1 KC pressure wave into a 1 KC electrical wave. This is rectified to produce a constant DC output.

All elements of a complete system have been assembled on the bench in order to determine where the major problems are. We are now at the point where we recognize the problems-and many severe ones are present-- and we are tackling them in a systematic way. Orders of magnitude of improvement are necessary in all elements of the system as well as in final packaging if we are to achieve a practical implantable device. We have, however, established the very important fact that conceptually we are on firm ground. We can produce electrical energy from the respiratory cycle although, to date, the power output is measured in microwatts rather than milliwatts.

III. Radiological Data Processing--Contrast Demarcation and Multicolor Presentation

This project was initiated in June to permit preliminary exploration of the feasibility of converting the radiological gray scale into a full color presentation. To expedite the work, a commercial color television set was purchased since a three color picture tube plus many of the electronic circuits and power supplies required for its operation could be adapted directly for our needs. Additional circuits were designed during the summer for converting black and white TV signals into a form required for full color presentation. In August, a relatively crude system was placed in operation and we were able to convert a standard black and white television program into full color.

On the basis of these encouraging early results, we are presently engaged in the construction of improved apparatus and we anticipate tying our color-coded system into the closed circuit TV system in the Department of Radiology at the Mary Fletcher within the next few months.

PROJECT VIII: COMPUTER APPLICATIONS IN CLINICAL PATHOLOGY

Investigator: Rex D. Couch, M.D., Assistant Professor of Pathology

Programmer: Edmund Shephard

Amount of Grant: $ 17,708

Progress Report - August, 1965

I. Current Projects

A. Quality Control Statistical Program

This program takes values of analyses of standard control serums tested over a period of 3 to 6 months, adding the new data at the end of each month, and calculates mean and standard deviations for each analysis. The results are output on cards which are listed to provide a working "wall chart" for the manual plotting of the data for the next month. These manual plots provide a visual check of quality control utilizing all the timely data. (FORTRAN)

B. Clinical Chemistry Statistical Program

All values obtained from every analysis in Clinical Chemistry are input to a statistical program in which the following are calculated: mean, median, mode, standard deviation, average deviation, per cent of observations over the mode, values at the 25th and 75th percentiles, interquartile range, and semiinterquartile range. This program has also been utilized to compute "normal quotient" values. The results obtained are utilized in studies on automatic limits evaluation, separation of truly normal from abnormal results, and in classification of laboratory tests with respect to their function and utilization. (FORTRAN and 1620 SPS)

C. Editing and Prototype Limits Evaluations Program

All input cards generated in the clinical laboratory are processed by this program first. After sample-sorting of certain critical card fields off-line, this program analyzes the data for input and technical or clerical errors by means of comparison to established limits. These limits are now arbitrarily set at what are believed to be physiologic limits. All data outside these limits are rejected by the program and identified for follow-up of the source of probable error. At the same time this program is helping to establish physiologic limits as the data accumulates. (1620 SPS)

D. Examination Evaluation Program

The answers from written examinations are entered on cards by means of Porta-punch stylets and are processed by the FORTRAN program. This program directs the reading of master cards containing correct answers and scores from other portions of the examination not to be machine-graded. The output includes test scores, frequency distributions of answers for each question, performance of upper and lower percentile ranks for each question, and means and standard deviations for the portion of the test that was machine-graded and for any other segments of the examinations that were furnished on input. In this manner the examination is not only graded, but can be objectively evaluated as well.

E. Test Result Pattern Analysis

This project was undertaken cooperatively with Doctor Donald A. B. Lindberg of the University of Missouri Medical Computing Center. Patterns of data from 4 chemical tests, sodium, potassium, chloride, and bicarbonate (serum electrolytes) were analyzed in patients from our 2 institutions and from data published by Bradham.[1] The most remarkable finding was the great similarity of data from the 3 institutions. Of interest to us was the fact that the most commonly occurring pattern in patients at the University of Vermont was not the normal one. This finding objectively supports our impressions that data from hospital in-patients should not be evaluated by means of statistical technics based on a gaussian distribution. The results of this study will be published.[2] (See also IIA).

F. Limits Evaluation Program

Our philosophy of limits evaluation consists of designing programs that will (1) simulate the clinical pathologist's checking of all values reported from his laboratory, (2) prepare the data in a way that will facilitate rapid reporting by automatic means, and (3) utilize the data itself as a tool to evaluate the results as they are produced. This program, still being written, consists first of comparison of all values to a predetermined set of limits that are thought to be the physiologic limits. Because of the nature of the results obtained from statistical analysis of the values, they are then to be compared to the interquartile range values for the particular substance. These values seem to divide the chemical tests into 3 groups, (1) confirmatory tests, (2) screening tests, and (3) interrogative tests, the latter being those tests utilized in defining broad diagnostic categories in problem cases. From this point limits evaluation differs from one test to another, depending upon which of the 3 categories it fits best. This is the current working hypothesis for limits evaluation.

[1]Bradham, G. & Gadsden, R.: Surg.,Gyn., & Obstet. 114:535-538, 1962.
[2]Lindberg, D., VanPeenen, H.& Couch, R.: AM. J. Clin. Path., Aug. '65.

II. Joint Projects with Department of Electrical Engineering

A. Recognition of Diagnostic Test Patterns

This project is beginning in cooperation with Dr. David Lai. Quantitative results of tests will be arranged in a 3 dimensional vector system. The resultant vectors of the data from individual patients will be analyzed and correlated with diagnoses. The areas of occurence of various diseases in this system will then be utilized to find other diagnostic combinations of test patterns by means of probability density analysis.

B. Transducer Design for Automated Clinical Chemistry Analysis

The problem of capturing chemical data from automated analyses for input has led us to believe that a peak-reading transducer with some computing capability could be produced at relatively low cost. A prototype instrument is being developed to scan signals from the spectrophotometer unit in timed sequence and to compute values based on standard specimens. These values would then be transmitted directly to a teleprocessing keypunch for completely automatic data input.

C. Instrument Development in Clinical Pathology

As a part of the training program in Clinical Pathology and the Graduate Program in Electrical Engineering a combined project in laboratory instrument development is being developed. The Chairman of the Electrical Engineering Department, Dr. Wilfred Roth, has extensive experience in instrument design and testing. It is our belief that laboratory instrument development can best be performed in a primarily non-commercial university environment. Laboratory medicine has a great need for the establishment of this type of research.

III. Facilities and Personnel

A. The system utilizes an IBM 1620 digital computer with 40K core storage. Card input and card and console typewriter output are available. A "stripped" IBM 407 Accounting Machine serves as an off-line printer. Data input is achieved with IBM 026 keypunch in tandem with IBM 1092/1093 programmed input keyboards. Transmission between the latter is through 401 series Western Electric Dataphones. An IBM 082 card sorter provides for preliminary card editing and checking at the input site.

B. Regular personnel in addition to the Principal Investigator are:

1. Full time programmer - writes major programs in 1620/1710 SPS; short programs may be written in FORTRAN II. Previous training includes extensive experience with IBM Unit Record equipment and IBM 1401 programming.

2. Input clerk - spends approximately 1 1/2 hours daily on current chemistry data input and 2 1/2 hours on old chemistry data back to July, 1964.

C. Part-time Personnel

1. Programming trainees - 2 currently working summer session in programming and data input. One is a mathematics major, the other enters Medical College, Fall 1965.

2. Systems engineer currently being made available for consultation and ongoing systems aid through the courtesy of IBM Corporation.

IV. Consultative Personnel Available

A. Computer technology - the Director of the UVM computing center and ancillary workers are available and have been invaluable assistance. An excellent climate of cooperation exists in this area.

B. Instrumentation - In addition to joint projects now underway, the Electrical Engineering staff provides constant aid and advice.

C. Statistics - Consultation in this discipline has been from numerous persons. In the summer of 1965, 3 full-time statisticians will be available, 2 of whom will be on at least half-time status with the College of Medicine.

D. Programming - The IBM Corporation has finished consultation and assistance in programming current projects. In addition, a programming instructor has been provided for assistance in a continuing course in FORTRAN offered to College of Medicine personnel by the Principal Investigator.

Diagnosis by Pattern Recognition Techniques

We have recently started to develop methods for machine diagnosis along the line of pattern recognition. Each patient is characterized by a sequence of n numbers which are the results of n tests and/ or symptom questionaires. In other words, a patient is represented as a vector in the n-dimensional measurement space. A technique for optimally partitioning the n space into disease regions has been developed. We are now in the process of trying it out.

Proceeding along this line, a problem immediately arises; viz., how to select the measurements. We have also developed methods for the selection of symptoms and/or measurements. These methods depend very much on the hospital patient discharge records. We are now in the process of collecting these data. Computer programs will be written for the proposed methods. These methods are described in detail in several internal memoranda. At this point, we foresee the need of many many computer hours.

We believe that the methods developed here are novel in solving diagnosis problems and will contribute greatly to the art of machine diagnosis. Of course, the final justification lies heavily on the results. Therefore, our immediate future work is in the computing of results by using these methods and the refinement of the techniques developed so far.

Most of the methods developed up to this point suffer from a drawback which relies heavily on the records of clinicians made on the patients. In other words, the machine must learn with a "teacher". In the first place, we shall develop a method to diagnose sub-disease groups of a major disease when the machine is not told what and how many sub-disease groups are there. After this is done, we will learn enough to develop more sophisticated techniques which will not rely so much on the hospital records though they are not dispensable.

PROJECT IX - DIMENSION - THEORETICAL ASPECTS OF METRIZABILITY

Investigator: Bruce R. Wenner, Assistant Professor of Mathematics

Amount of Grant: $7,696

Progress Report - August, 1965

The objectives will remain the same as those listed on the first proposal. The first area of investigation is nearing solution. A Nagata metric does necessarily have a dimension-preserving completion on separable metric spaces, and the principal investigator is now concerned with a non-separable metric space for which it seems likely that no dimension-preserving completion exists. If this should prove to be the case, the problem will be completely solved. This particular problem may be completed with the time supported by the first year of the grant.

The second and third objectives are not close to completion, and hence would constitute the bulk of the research under a second year of the grant.

Project X - Changes in Nucleolar Ultrastructure Related to Plant Development

Investigator: Beal B. Hyde, Professor and Chairman, Dept. of Botany

Amount of Grant: $3,600

Progress Report - October 7, 1965

The amount awarded to me on the NASA institutional grant has been largely spent on a Kinney Vacuum Evaporator. This piece of equipment is not yet fully installed - it requires a water cooling system and a special electrical lead. It will be used as soon as possible for preparing grids on which biological material will be mounted for electron microscopic examination. It is an essential tool for the long term development of electron microscopy at the University of Vermont. Longer term, it will be used for making carbon support films, metal shadowing replica techniques a variety of situations which require evaporation of metal in a vacuum.

Project XI - Lehrman-Symanzik-Zimmermann Formula as a Calcalational Technique in Field Theory S1

Investigator: Leonard M. Scarfone, Assistant Professor of Physics

Amount of Grant: $857

Progress Report October, 1965

The NASA support received by the present writer during the summer (1965) was applied to a specific problem within a more general educational and theoretical research project in physics. The solution to the problem was obtained and a report of this work under the auspices of NASA has been accepted for publication in the American Journal of Physics. An abstract of the paper is given below:

The one boson Lee model of a solvable field theory with nontrivial charge and mass renormalization provides an elementary example of the Lehmann-Symanzik-Zimmermann formalism. The basic quantities of interest in this method of calculation are the vacuum expectation values of time-ordered Heisenberg operators and by studying the analytic properties of the Fourier transforms of these functions, the first nontrivial subspace of the model is solved without resorting to eigenvalue equations. The full Lee model was recently analyzed with this technique and it seems pedagogically appropriate to carry out an analogous calculation in an even more elementary context.

Project XII - Calculational and Experimental Aspects of Entropy Determinations

Investigator: Claus A. Wulff Assistant Professor, Dept. of Chemistry

Amount of Grant: $12,706

Progress Report - October 8, 1965

A start has been made on the calculational aspects of this program. A number of entropies have been calculated by Second Law methods. These will form part of the input data for the proposed revision of "Latimer's Rules". A number of systems e.g. ethane, propane, isobutane, and neopentane have been selected for barrier height evaluations. Such an analysis has recently been completed for the methyl-thiophenes[1]. This author is currently working with the university administration on the preparation of a budget and the release of NASA Institutional Grant funds allocated for the period September 1, 1965 to January 31, 1966.

[1] H. G. Carlson, C. A. Wulff and E. F. Westrum, Jr., to be published.

APPENDIX

Project descriptions in the form of proposals as submitted to the NASA Sustaining Grant Advisory Committee.

PROJECT I - UNIFIED ENGINEERING SHOP

This is identified as a project for budgetary control purposes only. By Executive Committee action $6,025 of the grant fund was allocated for the purchase of specified equipment needed in the Unified Engineering Shop. Authorization was given for the purchase of:

Engraving machine
Filing Machine
Precision toolmaker's lathe
Abrasive belt finishing machine.

PROJECT II

Title: Experimental Study of Photoelectric, Optical and Surface Properties of Transition Metals.

Investigators: Albert D. Crowell and David W. Juenker, Professors
Department of Physics

Objectives: The long range objectives of this research are the continued study of the mechanism of photoelectric emission from metals, the elucidation of the character and causes of the optical properties of metals from the visible through the far ultra violet in terms of the crystalline and electronic structures of metals, and the investigation of the physical nature and electronic consequences of the interaction of molecules with metal surfaces. The objectives of the specific projects to be undertaken in the immediate future are:

a) To determine the optical constants of evaporated films and bulk specimens of molybdenum, tantalum, tungsten, and rhenium, as functions of wavelength in the visible and near-ultraviolet spectral regions.

b) To measure the photoelectric yield, and its electron energy distribution, from the foregoing metals, and to determine the dependence of these quantities on the orientation of the exciting field relative to the emitting surface.

c) The determination of the effects of a simple chemically active gas, specifically CO, or the electrical properties of thin films of transition metals such as Mo and Ni.

d) The study of the changes in photoelectric work function of Mo or similar metals produced by interaction of the surface with CO.

e) The measurement of the amount of gas adsorbed and the activation energies of desorption on metal surfaces (e.g. Mo, Ni) with areas of the order of 1.0 cm^2.

Justifications: The projects to be undertaken will initiate a systematic investigation of the photoelectric, optical and surface properties of transition metals at shorter wavelengths and in greater detail than hitherto achieved. As a group, these projects constitute an investigation of unusual scope, which through the correlation of a variety of measurements on the same materials may be expected to increase significantly the range of information and the understanding of the nature of the fundamental properties of matter.

Justifications of specific projects:

a) The values of the optical constants, and the range of their variation between the bulk and film forms of the metals are data directly applicable to the design of reflection-optical systems.

The spectral dependence of the optical constants can be interpreted in terms of electron energy transitions in the metal, and in this respect, the proposed experiment is needed to complement similar assays of the electron energetics of metals which have been, or will be, carried out at shorter wavelengths.

At wavelengths below about 300 mμ, a knowledge of the optical constants is necessary to the proper interpretation of photoelectric measurements.

b) The energy distribution of photoemitted electrons can be used in conjunction with the spectral dependence of the optical properties to establish the identities of electron energy transitions in the metal. The chances are poor that any excited states of the metals in question will fall within the range accessible to the quartz ultraviolet, but the proposed experiment will test a novel energy analysis method that can be adapted ultimately to work in the extreme ultraviolet.

The dependence of photoemission n the angle of incidence and state of polarization of the incident illumination (vectorial photoeffect) has direct application to the construction of polarization detectors. More important is the information it yields concerning the photoemission mechanism, and particularly the locality of the photoexcitation process and the transport of hot electrons to the surface.

c) The interaction of a molecule with a metal surface is frequently accompanied by a transfer or sharing of electrons between the conduction bands of the metal and the molecule. As a result the number of charge carriers and the details of the band structure are affected. By observing the resulting change in the electrical conductivity it is expected that some conclusions such as the direction of electron transfer, about the nature of the interaction can be drawn.

d,e) Valuable as studies on such heterogeneous surfaces as those of films may be, a more nearly ideal study would consist of the measurement of the change in some surface property of a known face of a single crystal and the simultaneous determination of the amount of gas producing the change. Since single crystal surfaces of known orientation of transition metals are available with areas of at most a few centimeters square, the available observable properties are severely limited and the measurement of the amount of gas is not possible by conventional methods. Projects (d) and (e) thus constitute an attempt to

Make an investigation under conditions which approximate more closely than usual a situation which can be analyzed theoretically.

Relationship to NASA's Mission:

The optical and photoelectric behavior of matter at wavelengths in the ultraviolet is basic to the development of appropriate optical instrumentation for the study of ultraviolet radiation in space. The change in the electrical and optical properties of metals produced by an interaction with molecules has consequences in predicting the lifetimes and the changes in operating characteristics of instrumentation used in space vehicles. The increasing usage of thin film components makes the present research of particular relevance.

Previous Work and Present Outlook: The general area of the research has been studied in various ways for many years by many investigators and the available literature is voluminous. A bibliography of all the pertinent research papers on the problems would run to many pages. Background relevant to the specific projects listed above may be briefly summarized as follows:

a) The optical properties of bulk samples of Mo, Ta, W, and Re have been surveyed from the visible through the extreme uv by one of the present investigators and his students during the past several years[1,2,3,]. Some wavelength gaps in the data between 200 and 700 mμ make it desirable to remeasure the optical constants in that region. Of the four metals, only molybdenum has been subjected to a comparative study of film and bulk specimens[4]. Since in that case prospects were good for devising a deposition technique which yields a film comparable in optical quality to a polished bulk surface, it is appropriate to explore the properties of films of the other metals as well.

b) The photoelectric experiment in view pertains to several areas of current interest, including hot electron transport in metals[5-7], vectorial photoelectric effect[8,9], and photoexcitation of electrons in thin films [10,11]. The second of these topics has been studied only in molybdenum[8], among the four metals of present concern. A cursory examination of a typical film of that metal[5] has revealed no vectorial effect at all, and one aim of the proposed study is to determine whether this is a general property of vapor-deposited films. Only one of the four subject metals in bulk form has been subjected to modern photoelectron energy analysis. While there is no reason to believe the others will exhibit unusual behavior, it is possible that photoemission from films of these materials will include a preponderance of slow electrons, an electrons, an effect that has been noted heretofore in alkali metals[10].

c) In spite of previous observations[12] of the changes in electrical conduction of thin metal films due to interactions with gas molecules, the number of systems studied is quite limited. A systematic study with a sequence of transition metals does not appear to have been carried out, nor has previous consideration been given to the changes in the complex impedance produced by gases, although the existence of such an impedance for films is known.[13] Work has begun at UVM[14] on the changes in DC resistance of evaporated Mo films following exposure to CO.

d,e) While it has been known for years that adsorbed gas changes the photoelectric work function of metals,[15] it has not in general been possible to simultaneously determine the amount of gas producing a given change. Eisinger[16] performed some studies on a single tungsten ribbon using a non-equilibrium method, but a general technique applicable to equilibrium situations with many types of gases and surfaces is not available. The measurement of work function changes can be accomplished by several techniques[15] on small surfaces, but the measurement of the amount of adsorbed gas in less than a monolayer on an area of 1.0 cm^2 poses difficulties. A method for measuring small amounts of adsorbed gas and activation energies of desorption using a radio tracer has been developed at the University of Vermont.[17]

References

[1] J. P. Waldron and D. W. Juenker, J. Opt. Soc. Am. 54, 204 (1964).

[2] L. J. LeBlanc, J. S. Farrell, and D. W Juenker, J. Opt. Soc. Am. 54, 956 (1964).

[3] L. J. LeBlanc, Ph.D. Dissertation, Univ. of Notre Dame (July, 1964), (to be published).

[4] C. T. Raymo, Ph.D. Dissertation, Univ. of Notre Dame (May, 1964), (to be published).

[5] M. J. Brienza, Ph.D. Dissertation, Univ. of Notre Dame (June, 1964), (to be published).

[6] R. N. Stuart, F. Wooten, W. E. Spicer, Phys. Rev. Letters 10, 7 (1963).

[7] J. J. Quinn, Phys. Rev. 126, 1453 (1962).

[8] D. W. Juenker, J. P. Waldron, and R. J. Jaccodine, J. Opt. Soc. Am. 54, 216 (1964).

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[11] G. A. Katrich and O. G. Sarbei, Sov. Phys.-Solid State 3, 1181 (1961).

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[13] Hirsch and Bozian, Physica 30, 258 (1964).

[14] T. Ansbacher, M. W. Dissertation, Univ. of Vermont (1965).

[15] Culver and Tompkins, Advances in Catalysis 11, 67 (1959).

[16] J. Eisinger, J. Chem. Phys. 27, 1206 (1957), 28, 165 (1958), 29, 1154 (1958), 30, 412 (1959).

[17] A. D. Crowell, J. Chem. Phys. 32, 1576 (1960).

Procedure:

a) Optical constants will be deduced from measurements of reflectance as a function of angle of incidence and/or degree of polarization. The subject materials will be purified and examined in a high-vacuum environment. In the case of thin films, thicknesses will be measured by multiple-beam interferometry, after the optical and photoelectric data have been obtained.

b) Photoelectric measurements will utilize a plane-parallel electrode geometry whenever possible, in order to permit electron energy analysis by a retarding potential technique. Provision will be made for magnetic confinement of the electrons to the interelectrode space. Such an arrangement has already been tried with good results (D. W. Juenker and M. Brienza (unpublished)). A novel arrangement will be used for film specimens. These will be deposited in tapered thickness on the hypotenuse face of a 45-45-90 quartz prism and illuminated from the rear, with light entering one of the prism's side faces and

exciting through the other. The near-total internal reflection prevents light from falling on the collecting electrode, and simple rotation of the plane of polarization serves the double purpose of varying the orientation of the photoexciting field in the film and providing an independent variable against which reflectance can be measured for an in situ determination of the film's optical constants. More conventional aspects of the procedure are outlined in reference 8 of the preceding section.

c) An apparatus for measuring the change in DC electrical resistance of Mo films by interaction with CO has been built. The apparatus is to be extended to permit (1) the simultaneous measurement of the amount of adsorbed gas (2) the determination of the weight and thickness of the film, (3) the observation of the changes in complex impedance either by a bridge method or a pulse-relaxation technique, or both, and (4) the simultaneous observation of the change in an additional parameter such as work function.

d) An apparatus has been built for studying work function changes of a polycrystalline Mo surface produced by gas adsorption using the Fowler method. Fowler plots on the clean surface and their changes due to background contamination of residual gas (press about 10^{-9} torr) have been obtained. Studies of the effects of CO at low pressures (10^{-7} torr) are about to be initiated.

e) A new apparatus for the measurement of the amount of adsorbed gas using a radiotracer (CO containing C^{14}) incorporating recent ultra high vacuum techniques (e.g. elimination of stopcocks) is being designed for construction within the next 6 months.

Probable Duration

The research is part of an ongoing and extensive effort that is anticipated to last for many years. It is expected that some material suitable for publication on the specific projects listed above will be produced by the end of the calendar year (1965). The appearance of actual papers in the journals can thus be expected by late 1966 or early 1967.

Amount of Grant Requested: $25,380

Personnel:

D. W. Juenker, 10% of time during spring term, full time two months of summer, 25% of time during fall term.

A. D. Crowell, full time for 1 1/4 month summer.

Two graduate assistants full time.

PROJECT III

Title: A Numerical Method for Determining Residual Stresses Resulting from the Sudden Heating of the Inner Surface of a Short Hollow Cylinder

Investigator: Howard Duchacek, Associate Professor of Mechanical Engineering

Objectives:

1. It is proposed that the numerical method for determining thermal stresses involving plastic flow in a constrained flat plate be extended so that a computer program will be written to determine residual stress which result from suddenly heating the inner surface of a short hollow cylinder.

2. It is proposed that a method be determined to specify the temperature distribution in a cylindrical ring, the temperature of the inside surface of which is a non-linear function of time.

3. It is proposed that an experimental program be conducted to determine the temperature, and strain during the heating cycle and the residual strain upon return to ambient temperature.

Justification:

The determination of residual stresses in a short cylinder which result from a sudden heating of the inner surface of that cylinder is very complex because of the variations of the parameters which occur during the heating period. The modulus of elasticity, the ultimate strength, and the coefficient of linear expansion, the specific heat, the thermal conductivity, may vary quite significantly during the heating and cooling period which takes place. A numerical method which takes account of not only the variations in these parameters, but also the variation of the stress analysis from an elastic to a plastic mode is most readily accomplished with a digital computer. The results of the work we have accomplished here is closely related to NASA's mission. The problem of thermal stresses in rocket nozzles, which result from a sudden heat condition on blast-off and the residual stresses which result from the heating and cooling are a significant concern of the space program.

Previous Work and Present Outlook:

The work we hope to accomplish here will rely on previous work accomplished here, and also upon the published results of others in this field. A list of references is here included to indicate the previous work which has been done:

The calculation of Temperature Stresses in Tubes - L. H. Barker. Engineering Vol. 124, p. 443, 1927

Thermal Stresses in Bodies Exhibiting Temperature - Dependent Elastic Properties - H. H. Hilton, Urbana, Illinois, Journal of Applied Mechanics, Vol. 19, pp. 350-354, September, 1952

A Contribution to the Theory of Internal Stresses in a Long Hollow Cylinder by T. Matsumura. Kyoto Imperial University, College of Engineering Memoirs, Vol. 3, #3, June, 1923, pp.61-80.

Theory of Plates and Shells, Timoshenko, McGraw-Hill Book Co.1959

Thermal Stress by V. E. Gatewood, McGraw-Hill Book Co., 1927.

An Introduction to the Theory of Elasticity by R. V. Southwell, 1941.

Transient Heat Conduction in Hollow Cylinder after Sudden Change of Inner Surface Temperature by R. L. Perry and W. P. Berggren, University of California Press, Berkeley, Calif. 1944.

Theory of Thermal Stresses by Bruno A. Boley and Jerome H. Weiner John Wiley, New York, 1960.

Stress Analysis of Rocket Nozzle Sections Subjected to Pressure and Radial Temperature Gradients by Anthony S. Dadario, Report AD240685, (ASTIA) Technical Memorandu, RAD-7 TM-60-46 Contract AF)4(647)-258, AVCO Corp.

Reduction of Severity of Thermal Shock Stress of a Thermal Clamp Plate by Previous Sudden Heating of the Same Surface, Progress Report, May 30, 1964 to Naval Research Laboratory, Howard Duchacek.

A Computer Program to Determine Thermal Stresses Involving Plastic Flow Progress Report, August 30, 1962 to Naval Research Laboratory, Howard Duchacek.

Numerical Method for Determining Thermal Stresses Involving Plastic Flow NRL Report 5755, I. Vigness and E. W. Clements, Naval Research Laboratory.

The additional information which this project is expected to contribute is indicated under objectives and justification.

Procedure:

The procedure to be followed in accomplishing the objectives are as follows:

A computer program will be written immediately following a stress analysis of a short cylindrical element. A computer program will also be written to determine the temperature distribution within a cylindrical ring as determined also by the computer program. An experimental program will be initiated to determine the strains which occurred during the heating cycle and also during the cooling cycle. Tests will then be made upon the ring to determine the formation which occurs following return to ambient temperature. The work is to be performed in the Votey Engineering Building, University of Vermont where a 50 killowatt plasma jet is available. The IBM 1620 Computer at the University of Vermont is also available for use in this portion of the program.

Probable Duration:

It is estimated that the time required to complete the research and publish the results will be approximately two years.

Amount of Grant Requested: $12,000

Personnel: Principal Investigator - 1/4 time during academic year and full time for two months in summer.

2 Graduate Assistants - 1/2 time during academic year and full time during summer.

PROJECT: IV

Title: Individual differences in the influence of sensory isolation upon intellectual, emotional, and physiological functioning.

Investigator: Donald G. Forgays, Professor and Chairman, Department of Psychology

Objective: This project attempts to evaluate the influence of individual differences in the effects of rather complete sensory isolation. Additionally it will examine the modification of such influence which may result from the homogeneous or heterogeneous stimulation of the subject during isolation. The project will also survey the relative acceptability of a variety of input signals during isolation. Finally, the persistence of any changes attendant to isolation (intellectual, emotional, or physiological) will be studied.

Justification: 1. Such research will contribute basic information concerning motivation, both theory and function, and may contribute also to brain function theory.
2. Such research will contribute specifically to knowledge concerning isolation effects and their control; such knowledge is vital to NASA operation which includes the relative isolation of humans in the space program.

Previous Work: The pilot studies of Lilly (1956) and of Hebb's students and colleagues (Bexton, Heron, and Scott, 1954), concerned with the effects of sensory deprivation upon cognitive and perceptual functioning, led to a good deal of concern with the problem and several attempts to investigate it further (Doane, Mahotoo, Heron, and Scott, 1959; and Wexler, Mendelson, Leiderman, and Solomon, 1958). There are two excellent summaries of pertinent observations and theory presently available (Wheaton, 1959; Solomon, et al., 1961).

These studies report, in general, deleterious effects of sensory deprivation upon a variety of intellectual tasks (intelligence test sub-tests, rotary pursuit, etc.) and emotional responding (attitude change, affective modifications). However, a review of this literature indicates quite clearly that relatively little systematic experimental investigation has taken place in this problem area; many of the observations are based upon extremely limited samples, while others were not made under rigorously controlled conditions. Secondly, there appears to have been no attempt to study systematically the relationship

between individual difference factors and susceptibility to the influence of sensory isolation. This is especially curious since most of the workers in the area comment on the great import of individual factors, especially personality variables. Ruff, Levy and Thaler (1961) report individual variation in such effects, largely attributable to individual differences in motor behavior, sleep and eating patterns, and the like. They did not select subjects on the basis of these variables but rather interpreted their data post hoc in an attempt to explain their findings. Goldberger and Holt (1958, 1961) and Holt and Goldberger (1959) also present data relating to individual difference effects. Finally, literature in this area seems totally lacking with respect to an analysis of the persistence of any deleterious effects of isolation. The few experimental projects which exist usually provide data taken from subjects during or shortly after isolation. Changes which may have occurred on these measuring occasions were not systematically studied over time to observe return to normal, if such takes place.

In several pilot observations recently, the writer has observed that there are wide variations in effects of isolation upon a number of subjects, largely colleagues, tested. Interestingly enough, the differences appear to be related to the professional categories (academic speciality) of these subjects, which in turn, appear to be personality related. It is these pilot observations which will be expanded systematically in the present series of studies.

Procedure:

Subjects will be selected from among available faculty, graduate and undergraduate students at the University of Vermont. They will be chosen on the basis of a series of psychological tests, including the WAIS, MMPI, EPPs, Rorschach, TAT, etc. Subject categories will include average (normal) profile, single extreme score profiles, multiple extreme score profiles, and so on.

Each subject will be isolated for up to 24 hours maximum (this appears to be an effective isolation period according to available studies) by total immersion in a heated water tank with appropriate breathing equipment but no contact with the tank except by a suspension strap. Two-way intercom. is provided for experimenter monitoring. Subjects will not be told the duration of the stay but, rather, asked to be prepared to stay for a full 24 hours.

Each subject group will be broken down into three sub-groups:

a. The first will be asked to remain without moving in the tank for the period of confinement.

b. The second group will be provided homogeneous stimulation throughout the stay: Pure auditory signals fed in regularly. They will be given the opportunity of receiving "boring" reports from time to time (stock market pages read to them, etc.).

C. The third group will be provided heterogeneous stimulation throughout the stay: mixed auditory signals (music, etc.) piped in during the stay. They will be given the opportunity to receive "interesting" reports from time to time (problems to be solved, etc.).

All subjects will be subjected to testing shortly after removal from the isolated environment (any subject may leave at any earlier time upon his request). Tests will include a variety of intellectual tasks, perceptual-motor tests, personality assessment, etc. Throughout the stay in isolation subjects will be encouraged to report on any phenomena which may be occurring (such as frequently reported hallucinatory activity); these will be recorded.

Spot testing in all test categories will continue every 24 houds until all differences which are observed dissipate.

Probable Duration:

The entire project is estimated to require three years. It is anticipated, however, that the original 50 subjects will be tested within the first year and that at least one publication will be based upon this information. The second and third years will retain the same experimental design, unless otherwise indicated by initial data, will involve the testing of at least 50 additional subjects per year, and should lead to several research publications.

Amount of Grant Requested: $15,000

Personnel:

Principal Investigator - full time for eight weeks in summer and 25% time during academic year.

Two associate investigators - full time for two weeks in summer.

Two graduate assistants for ten weeks in summer.

One graduate assistant during academic year.

PROJECT V

Title: Smooth Muscle Activity as Recorded by Radio Telemetry

Investigator: Kenneth R. Simmons, Assistant Professor, Animal and Dairy Science Department

Objectives:

The objectives of this proposed project are as follows:

1. To develop radio telemtry techniques for monitoring and measuring smooth muscle activity.

2. To test improved transmitting devices for smooth muscle electromyography. These devices will be designed and constructed by the Electrical Engineering Department of the University of Vermont.

3. To use these devices and techniques to measure smooth muscle activity primarily in domestic animals. These same techniques should also be applicable to studies of human smooth muscle activity.

Justification:

By the use of radio telemetry, physiological changes in animals can be measured under a prescribed environment. Such equipment alleviates the following: restraining the animals, molesting them by the attachment of external measuring devices, and the possible disconcerting presence of an investigator. Transmitters can be implanted within the body to measure the electric potential of muscles. These transmitters can be made to operate for comparatively long periods of time without abnormally effecting or exciting the animals. Data obtained with the use of these devices will be of both practical and basic scientific value in relation to studies of smooth muscle activity.

Previous Work:

The technique of radio telemetry is not new [14,21] but unfortunately it has not progressed as rapidly as originally hoped for [21]. In many cases preliminary publications describing the transmitters have not been followed by subsequent papers concerned with the physiology involved or with further improvements in the devices. The cooperative efforts of both the physiologist and the electrical engineer appear to be necessary for success. However, it seems certain that improvements in the techniques of miniaturization and high-frequency solid state electronics will improve and expand the use of telemetry devices for recording physiological functions.

Telemetry has been used to record pressure changes within the gut of humans [2,9,10,16], cows [1], and sheep [5]; and voiding pressures within the bladder of humans [12]. Pressure changes have also been recorded within the uterus of pregnant women [20]. Many investigators have said that their telemetry devices could be used to measure temperature in the body, but there have been practically no reports of this application in human physiology [14]. However, telemetry has been used to record temperatures of incubating penquin eggs [7], dolphins [15], sheep [3], and cows [6].

Many of the physiological investigations using telemetry have been applied to transmitting and recording EKG and EEG [4,8,11,14,18,21]. Similar transmitters have been used in the recording of the electric potential of striated muscle [13,17].

Preliminary studies were conducted at the University of Vermont during the past year [19] with the assistance of Dr. A. E. Dracy (on leave from South Dakota State College) and Dean W. O. Essler of the College of Technology, University of Vermont. Rabbits, sheep, and cows were used in these studies. Electrodes from an EKG transmitter were implanted in the uterus of these animals and records were made before and after administering oxytocin or atropine. These preliminary studies indicate that it is possible to record telemetry signals of uterine muscle activity using devices designed and built by Dr. Essler.

Procedure of Work to Be Done:

Since the author's experience and interest pertains to reproduction, it seems logical to experiment primarily with the smooth muscle of the uterus. A method for studying uterine activity *in vivo*, and under different hormonal states, would be of great value and significance in relation to studies of reproduction; e.g., sperm and ovum transport, early embryonic mortality, gestation, and parturition. Identical devices and techniques could then be applied to studies of other smooth muscle systems such as those of the gastrointestinal tract.

Rabbits will be used as the primary laboratory animal because of their size. Techniques developed with rabbits would then be applied to sheep and cows because of the economic importance of these two species.

The areas of investigation will be as follows:

1. To adapt the so-called EKG transmitter to smooth muscle electromyography.

2. To determine the proper type of electrodes, and the best method for for implanting them in the uterine myometruim.

3. To determine how long electrodes can be left in the muscle and still give an accurate interpretation of its electric potential.

4. To determine if differences exist in electric potential at various locations on the uterus.

5. To determine the most suitable location for implantation of the transmitter.

6. To compare results obtained in these investigations with the more conventional approaches to muscle activity studies. For example, a comparison could be made between the electric potential of muscle activity and actual contractions as recorded by strain gauges or myographic transducers, and pressure transducers within the uterus.

7. After the above techniques have been perfected recordings will be made of uterine activity, as measured by its electric potential, under different physiological (hormonal) states. Recordings will be made throughout the estrous cycle, during breeding, gestation, a and parturition.

The work will be carried out in the Animal & Dairy Science Department. Facilities are available for housing and care of animals. The basic recording device is part of the equipment already available.

Probable Duration:

Parts one through six of the procedure should be completed by February 1, 1966. Some portions (recordings of electrical potential of uterine muscles under different hormonal states) of part 7 should be completed, but recordings during the estrous cycle, gestation and parturition will undoubtedly take longer and would therefore require additional support; this would be especially true if the observations are made in sheep and cattle.

Amount of Grant Requested: $3,354

Personnel:

Principal Investigator - 75% of time.

PROJECT VI

Title: Distribution and Physiological Effects in Brain of Currents From External Electrodes.

Investigators: Stanley Rush, Associate Professor, Electrical Engineering Department. Wilfred F. Chambers, Associate Professor, Anatomy Department.

Objectives:

Specific objectives of Program.

Primary:

(a). To obtain detailed maps of current distributions inside brain due to external electrodes.

(b). To duplicate locally in different areas of the brains of experimental animals the same current densities which from external electrodes produced electro-narcosis. In this way it should be possible to determine the area or areas of the brain which are responsible.

(c). To develop and verify a theoretical explanation based on the data of part (b) of the mechanism of electro-narcosis.

Secondary:

(a). To determine the resistivities of the tissues important to determining the above current distribution, particularly the skull.

(b). To ascertain optimum locations of external electrodes and frequencies of current for electro-narcosis, electro-shock and rheology.

Justification:

The potential applications of electro-narcosis are many. The possibility for simplified safe anesthesia is very strong. Improvements over the present promising but still inadequate techniques should follow from better fundamental understanding of the physical and biophysical processes involved. "Fall-out" benefits of this work may yield information leading to a better understanding of and improvement in electro-shock and rheoencephalography. The knowledge to be gained from this program will contribute to medicine generally and may have particular application to future space requirements as yet unforeseen. The data to be obtained for impedance plethysmoraphy in the brain may have immediate application in the monitoring of physiological variables under the stresses of space exploration.

Previous Work and Present Outlook:

Considerable work has been done with current stimulation of the brain from electrodes outside the skull. These have application to such areas of medical interest as electrical anesthesia, rheology and electrical shock treatment. Many combinations of electrode placement, current waveform and electrode types have been employed and results compared (1,2). Little or none of this work appears to have taken advantage of the physical principles of electromagnetisim which are directly applicable to the study of current flow in volumne conductors.

Procedure:

In the proposed study, a physically founded program would be undertaken to determine the interrelation between the externally generated currents and the sites within the brain which produce anesthesia. Incidental to this program, the electrical properties of the skull and brain would be determined and the current distribution within the brain due to any combination of external electrodes would be specified.

The first phase of this program would be a theoretical and experimental study of the electrical properties of the scalp muscles, skull and brain and their combined effect on current flow from a given electorde pair on the body and/or skull surface. Considerable work has been done on measurements of the body tissues, although not too reliable data exists for skull and brain (3,4). In particular, extensive measurements of the skull resistivity are presumed to be intimately related to the porosity and thickness, which are variable over its surface. There are macroscopic openings such as the orbit, carotid canal and hypoglossal canal as well. The techniques of exploring the resistivity and mapping the current field are well known in physics. The specialized features of applying these techniques to biological materials have been developed in the extensive work on electrocardiographic and similar studies. Once the physical parameters of resistivity have been established, both theoretical and physical simulation techniques can be employed to determine the relations between externally applied currents and the current fields within the brain.

The second phase of this program would attempt to re-produce, with internally embedded electrodes in local areas of the brain, the current distribution of externally placed electrodes which produce electrical anesthesia. By successively reproducing these local current distributions in different regions, the areas of the brain responsible for electrical anesthesia can be found. Once this region has been determined, optimization of current

Strength and waveform can be conveniently investigated, free from the artifacts of external electrode connections. Based on the previous phase investigations, optimization of external electrode placement can be determined.

The third phase would be the development of a biophysical model of the mechanism of electro-narcosis. This involves the generation of suitable hypotheses and the conducting of experiments to test them.

Probable Diration:

The first phase of this program should be completed in about one year's time at the prijected level of effort.

The second and third phases should cover about a year each also, for a total of three years.

Amount of Grant Requested: $16,870

Personnel:

Principal Investigator -	Full time, summer 25% time, academic year
Graduate Student -	Full time, academic year
" "	50% time, academic year

PROJECT: VIIA

TITLE: Bioenergy Electrical Sources

Principal Investigator: Wilfred Roth, Chairman and Professor
Department of Electrical Engineering

Objectives:

A. To study energy forms in the body having levels of several hundred milliwatts.

B. To consider possible means for converting such energy into useful electrical form.

C. To develop specific means for accomplishing such energy conversion.

D. To develop implantable bioenergy sources to provide power for molecular electronic devices and artificial organs.

Justification:

1. to achieve the above objectives, a more detailed picture of the energy balance existing in various organs in the body must be obtained. This information will be useful for many other purposes as well. In addition, efficient energy converters operating at very low power levels will have to be achieved. Such techniques may lead to interesting new sensors useful for other applications. New materials to permit permanent implantation in biological tissues will have to be exploited and these too will be useful elsewhere.

2. Successful achievement of the objectives will permit numbers of sensors to be implanted within the human body without requiring batteries. Telemetering techniques can then be used to transmit biological data outside the body for telemetering from space stations to earth through more conventional communication links. Thus, more detailed continuous monitoring of important biological data will be provided.

Previous Work and Present Outlook:

Research to develop biological sources was initiated in other institutions in 1960. The work to date has been concerned, primarily, with heart pacemakers rather than the development of general electrical sources. Research has included electrochemical cells, piezoelectric transistors surrounding the aorta, piezoelectric accelerometers attached to the heart and spring wound clock movements driven from motion of the diaphram. Six primary references are noted:

1. W. Chardack, A. Gage and W. Greatbach, "A transistorized self-contained implantable pacemaker for the long-term correction of complete heart block", Surg., vol. 48, pp. 643-654; October, 1960.

2. P.M. Zoll, H. A. Frank, L. R. N. Zarsky, A. J. Linenthal and A. H. Belgard, "Long-term electric stimulation of the heart for Stokes-Adams disease", Ann. Surg., vol. 154, pp. 330-346; September, 1961.

3. Parsonnet, V., G. H. Myers, I. R. Zucker, H. Lotman and M. M. Asa. 1963. A cardiac pacemaker using biologic energy sources. Trans. Amer. Soc. Artif. Int. Organs. 9:174:

4. Parsonnet, V., I. R. Zucker, H. Lotman, G. H. Myers and M. M. Asa. A self-perpetuating, biologically-energized cardiac pacemaker. Surg. Forum. In press.

5. G. H. Myers, V. Parsonnet, I. R. Zucker, H. A. Lotman, M. M. Asa, "Biologically-energized cardiac pacemaker", IEEE Trans. Bio-Med. Electronics, BME-10, #2; April 1963.

6. V. Parsonnet, G. Myers, I. R. Zucker, H. Lotman, "The Potentiality of the Use of Biologic Energy as a Power Source for Implantable Pacemakers", Am. N.Y. Acad. Sc., Vol. 111, pp. 915-921; June, 1964.

Such methods have generated microwatts of power but in ways that lead to questions regarding long time compatibility with biological tissues. For example, a piezoelectric sensor surrounding the aorta operates but it affects the elastic behavior of the aorta walls. Over a long period of time questions arise regarding how well the aorta will tolerate such treatment. Passive converters are required that should be tolerated by the body for many years and higher efficiency, higher power output methods are necessary in order to operate artificial organs of the future.

Procedure:

A. A study of medical text books and periodicals describing energy balance in the body is necessary. This work is presently under way.

B. Classification of possible mechanisms in terms of feasibility and possible power levels will produce an order of priority for further investigation. Those mechanisms with the highest energy level capability will be considered first. Classification is well under way and specific means for energy conversion are presently under investigation from a theoretical viewpoint.

C. Upon completion of present activities described in A and B, those energy conversion methods showing the best prognosis for success will be pursued. Large scale engineering models will be constructed and measurements and performance characteristics will be determined. Measurements of efficiency and power level will be emphasized. Problems associated with long term life under absolute reliability conditions will be analyzed and attacked. This work, for the most part, will be performed extra corporeally until progress is sufficient to justify miniaturization for implantation in animals. This work will be performed initially in Room 320 Votey but will be moved to 307D at a later date. Usual electrical measuring instruments and oscilloscopes common to any electrical engineering laboratory will be required. In addition, present thinking incorporates hydraulic transmission and logic circuits in some proposed embodiments, thus fluid stream measuring instruments will also be required. Finally, a recording oscillograph will be necessary at a later date. Some special purpose test equipment will have to be designed and constructed to simulate certain organs of the body for example, the diaphragm, the rib cage, and the like. These will be done as required by progress of the experimental program.

D. Upon sucessful completion of extra corporeal engineering models the program will be shifted in emphasis from feasibility models to practical embodiments for implantation. These will involve microminiaturization techniques to permit minimum packaging, questions of materials compatibility with body tissues and fluids, and questions of long term use in continuous operation. The animal room in Votey will be useful here for experimental implantation.

Probable Duration:

Elements A, B and C of this program should be completed within a twelve month period if two graduate students are available. It should be emphasized, however, that a multi-pronged attack investigating numbers of possibilities at once in sequence is possible to solve this problem. Therefore, as new energy conversion approaches are contemplated, revision in the program may be indicated. The duration of Element D of the program is more difficult to predict. Miniaturization techniques to provide maximum capability in minimum space can be time consuming and since small laboratory animals will be utilized for initial implantation experiments, even less space will be available than in the human body. However, it is estimated that substantial progress on implantable embodiments of one or more energy converters will be made in a second twelve month period.

Amount of Grant Requested: $17,280 (includes Project VIIB)

Personnel:

Principal Investigator - 1/4 time, academic year, 1/2 time, summer.

Two graduate students - 1/2 time, academic year, full time, summer.

PROJECT: VIIB

Title: Radiological Data Processing--Contrast Demarcation and Multicolor Presentation

Principal Investigator: Wilfred Roth, Chairman and Professor
Department of Electrical Engineering

I. INTRODUCTION:

An X-ray plate contains an enormous wealth of information in the technical sense of stored bits per square inch. A group of skilled radiologists will be unamimous about many conclusions to be deduced from areas of an X-ray plate, but there can be much disagreement about interpretation of less obvious regions of a plate. There is often difficulty in translating or interpreting stored data on the X-ray plate into clinically important evaluations.

On the basic assumption that there is more stored information on an X-ray plate than can be interpreted by the average skilled observer, this proposal is directed toward two specific efforts to render X-ray plate data more meaningful. The proposal concerns the subjective interface between the data stored on the X-ray plate and the conclusions reached by the human reader.

II. TECHNICAL DETAILS:

A. CONTRAST DEMARCATION

The nature of the human eye is such that absolute light intensity levels are difficult to estimate. The eye is basically a contrast gradient sensor in which changes in light level per unit of distance of the image on the retina create a meaningful sensation. Thus, when an observer views a screen on which two different light levels are widely separated, he may not be able to perceive the level difference. If the same two contrasting light levels are now moved closer together, a reduced separation will be reached wherein the observer will readily recognize that two light levels are indeed present.

Interpretation of an X-ray plate is made difficult when contiguous areas blend smoothly one into the next--i.e. a low contrast gradient exists. For example, in searching for the coronary artery, a vague contrasting region may be observed and a skilled reader may conclude that he is in fact looking at the artery--but it certainly is not as striking as the image of a rib might be.

An electronic light sensor is inherently an absolute light level device in contrast to the gradient sensing properties of the human eye. As such, it can be relied upon to produce information regarding changes in light level regardless of spacial separation. Consequently, scanning of an X-ray plate by photosensing means can detect when contrast shifts greater than a pre-selected amount occur. Electronic circuitry can be devised wherein a change in light level greater than this preselected threshold is used to introduce an electronically generated intensifier pulse. If the scanned image with the superimposed intensifier signals is displayed on a television type monitor, an electronically generated margin line will appear around any regions in which contrast change exceeds the threshold. The result will be similar to that obtained by drawing a dark line around particular regions of interest in a photograph--contrast demarcation is achieved.

By combining a contrast emphasizing unit with existing components of a television scanning radiological setup presently in use at both the Mary Fletcher and De Goesbriand Memorial Hospitals, the margin emphasis described above can be accomplished.

B. MULTICOLOR RADIOLOGICAL DATA PRESENTATION

Although the human observer has both light level or contrast sense and color sense, viewing of X-rays does not utilize the color discrimination ability of the observer--only the grey scale is utilized. It is possible to develop a color encoder to convert the grey scale x-ray presentation into a full color presentation on a color TV monitor. It is proposed that a research project be initiated to determine whether such presentation will, in fact, enable the skilled observer to interpret more of the information presently stored on a conventional black and white X-ray plate.

Since the psychology of color viewing imparts perception of sharp detail to the black and white response of the eye, color must not be looked to for supplying detail information. On the other hand, a multicolor rendition of the hand in which the central regions of the bones might be green, the outer edges of the bones might be blue and the bone tissue around the joints might be red should have marked impact upon the observer.

It is proposed that such a color encoder be developed to operate in conjunction with the television equipment already on hand at the University as discussed in Section A above. Initial experiments using three colors--the three beams of a conventional color TV picture tube--would suffice for preliminary exploration. If the impact of such a preliminary approach is striking, the full multicolor solution would then be sought. The electronic embodiment of such an encoder would be complex but it can be accomplished within the present state of the art.

C. MULTICOLOR PRESENTATION PLUS CONTRAST DEMARCATION

A combination of the contrast emphasizer discussed in Section A with the multicolor presentation discussed in Section B should be useful. This can be illustrated by taking a full color picture and outlining regions of luminance change with a narrow black line. Efforts to combine the two ideas will represent a third phase of this project.

III. PERSONNEL AND FUNDING

The projects proposed herein can be conducted by a mature graduate student working with the principal investigator. It is hoped that this work can be initiated in June of 1965 so that full-time effort during the summer can be applied to the work.

In view of the low expenditure during the spring of 1965 on the principal investigator's NASA Grant "Bioenergy Electric Sources", it is proposed that sums be made available from this to cover at least initial efforts during this summer on the new projects. If results show some promise by the fall, the question of continued financing can be examined at that time.

Amount of Grant Requested: Included in Project VIIA

Personnel:

Included in VIIA

PROJECT VIII

Title: Computer Applications in Clinical Pathology

Investigator: Rex D. Couch, Assistant Professor, Department of Pathology

Objectives:

The purpose of this project is to explore the vast possibilities offered by computer techniques in the fields of medical research and patient care. This new area of data storage, retrieval and manipulation now makes it feasible to examine in any desired detail data from cancer control procedures, heart disease statistics, or any other objective data in medical care and research. Whole populations of patients can be studied with respect to a given laboratory test, therapeutic procedure, or clinical research problem by means of data processing equipment.

In order to define the feasibility of such a program we propose to examine clinical laboratory data from the Mary Fletcher Hospital to study the practicability of coding and formatting of test results for input to computer processing. In short computer programs already tested, we have found that processing clinical laboratory data is possible. It now remains to be investigated as a continuous processing problem which requires more "streamlined" programming effort, development of an integrated system of processing, and provision of output on a day-to-day or week-to-week basis.

The specific clinical laboratory data manipulations we wish to study involve systems for calculations and comparisons of laboratory values with various statistical evaluations. This includes comparisions of a patient's values with his own previous ones, comparisons of individual and group data, and statistical correlations, normal value determinations, and quality control studies utilizing patient data. These studies will progress into specific correlations between laboratory data and disease processes as expressed in discharge or surgical pathologic diagnoses and in tumor registry follow-up data. We also wish to study the feasibility of producing work schedules, cost evaluations, and monthly statistical service reports to aid in evaluation of laboratory efficiency.

Justification:

The implications of the work are many and, we believe, are of real significance. It is possible, once the data is in "machinable" form, to attack the problems of limits evaluation, pattern analysis, and quality control, to mention only a few. It is not clearly known what the real limits of normal are for many of the physiological tests we perform daily. Through careful statistical evaluation of the data we can derive meaningful parameters by which these normal limits can be judged. In addition, those values that lie within normal limits may form a pattern that indicates early stages of disease, before the disease is clinically or pathologically evident. The requirements for analysis of this kind are stringent. The data must be as accurate as possible, and careful sophisticated technics must be developed. The concept of quality control is still in its infancy, largely because the accumulated wealth of data that bears on the problem has been unavailable. Not only must the evaluation of technics be promulgated, but the patient data can also be utilized to establish significant relationships with control data.

The impact of the project upon the mission of NASA is three-fold: (1) We must first know the limits, the patterns, and the complex interrelationships of physiologic variables in our current environment before complete evaluation of the effects of environments that are now foreign. (2) New and better technics must be continuously under development in order to derive all that the data can "tell" us. (3) New and dynamic methods and equipment must be developed in order to achieve the greatest possible accuracy and feasibility in the study of man in his relationship to the outside world.

Previous Work Done:

The applicant has worked for nearly a year now in preliminary outlining of codes and formats, in FORTRAN programming and familiarization with the IBM 1620 computer, and in developing the basic system planning for this project. These developments have been undertaken along with study of other computing facilities in order to make this pilot study fit in with possible future uses of other equipment if the proposed project is found to be feasible. We have collaborated with investigators from the University of Missouri Department of Pathology in a study entitled: "Patterns inClinical Chemistry: Low Serum Sodium and Chloride in Hospitalized Patients" to be published in the American Journal of Clinical Pathology. August, 1965.

Procedure:

Patient data from the clinical laboratories of the Mary Fletcher Hospital will be put onto punched cards by means of a special input device, the IBM 1092 input terminal, connected to an IBM 026 keypunch. Codes, formats, and special input problems have been under study for about six months. Much has already been developed, and much more will be aided by consultation with the Director of the Medical Computing Center of the University of Missouri. We have visited this facility and have already received considerable assistance and advice.

The first step in this project, then, is to make clinical data available in a form that can be processed by a computer. This involves the coding of all tests, diagnoses, and follow-up data, the arrangement in meaningful formats for input, and the provision of proper data checks to insure accurate input. While the ultimate objectives also include systems analysis and programming for internal (magnetic tape or disc file) storage, the initial storage will be by means of punched cards. Intimately involved with arrangement of data for input is programming. This programming, already begun here at the University of Vermont, in addition to data formats and programming aid from other centers, will be an integral part of the initial phase of the project.

The processing of data on punched cards will be done with the IBM 1620 digital computer utilizing FORTRAN programming language. The programs will be written and tested first, for input with appropriate sequential runs designed to utilize the output of one portion as a part of the input for the next one, an important concept in a card-oriented system. Programs will then be written for the various processing procedures outlined under (A) above.

There are currently five residents (or Fellows) in Pathology studying computer data processing and FORTRAN programming. We propose to utilize this project in teaching, in some depth, computer applications and specific problems therein such as programming and systems planning.

Probable Duration:

This project is an on-going one that we believe will continue for some years. We expect that publications will continue throughout the duration of the project. The current phase of initial programming and development of data acquisition technics will last approximately two years.

Amount of Grant Requested: $12,480

Personnel:

Principal Investigator - 40% of time for one (1) year

Junior Programmer - 100% of time for one (1) year

Programmer Trainee and Clerk - 100% time for one summer

PROJECT: IX

Title: Dimension-Theoretical Aspects of Metrizability

Principal Investigator: Dr. Bruce R. Wenner
Department of Mathematics

Objectives:

1. To determine whether a Nagata metric necessarily has a dimension-preserving completion.
2. To attempt to discover other necessary properties of a Nagata metric.
3. To construct a topology-preserving metric which is of Nagata type on uncountably many closed subspaces.

Justification:

A Nagata metric makes dimension-theoretic properties of a space easier to study; hence new insight may be gained into the topological structure of metric spaces, and therefore on continuous transformations between metric spaces of arbitrary dimension. Problems involving such transformations frequantly occur in studying thermodynamics and fluid flow.

Previous Work and Present Outlook:

We say a metric has the Nagata property on an n-dimensional space if the boundary of every E-sphere is at most (n-1)-dimensional. J. Nagata has shown that every finite-dimensional metric space S has a topology-preserving metric which is Nagata on S, and the principal investigator has shown that any arbitrary metric space has an equivalent metric which is Nagata on countably many finite-dimensional closed subspaces. A theorem of K. Nagami has then been invoked to demonstrate the existence of a dimension-preserving completion of this particular metric. With this backlog of existing results the prospects are good that a yes or no answer can be obtained to the first objective of this project. For the second and third objectives the groundwork will have to be laid by the principal investigator, so the outlook is uncertain.

Procedure:

Paper-and-pencil work, combined with studying the literature.

Probable Duration:

There are good prospects for the attainment of the first objective within the year. Progress towards the second and third objectives is desired but by no means assured, in view of the amount of preliminary work which will have to be done by the principal investigator.

Amount of Grant Requested: $7,560

Personnel:

Principal Investigator - 1/2 time for one year.

PROJECT: X

Title: Changes in Nucleolar Ultrastructure Related to Plant Development

Investigator: Beal B. Hyde, Chairman
Department of Botany

A. The specific aim of this project is a clear description of changes in the ultrastructure of the nucleolus in cells which are undergoing some type of differentiation. More detailed aims include (1) the ultrastructural meanings of the old cytological terms - nucleolar organizer and associated heterochromatin, (2) the morphological inter-relation of the Chromosomes to the nucleolus during meiosis as well as at mitosis, and (3) changes in the ultrastructure of the nucleolus during the maturing of the seed when protein is being actively synthesized and stored.

B. Procedures

While certain standard light microscopic procedures -- particularly histochemical -- will be employed for general orientation, the electron microscope will be the primary tool in this investigation. For the project period covered by this proposal the procedure will be as follows. At least two plants for which standard seed is available will be utilized. One plant will be Plantago ovata, a plant grown in India because of the pharmaceutical value of its seeds. It has been selected because it is small, easy to grow, and its chromosome morphology has been described in detail (Hyde, 1953). The other plant will probably be rye, selected because uniform seed is available, because it is in a different group of plants, because its chromosome morphology and behavior has also been studied in detail, and because the author is familiar with its meiotic cycle.

In some cases seeds will be germinated until the primary root is growing at a uniform rate. The root tip will then be excised and prepared by standard procedures for electron microscopy. In other cases, whole plants will be grown to flowering and the anthers collected and prepared for a study of the nucleolus at meiotic prophase. Lastly, plants will be pollinated and embryos in various stages of development will be collected for a study of the nucleolus during the stages of rapid accumulation of protein.

Several complementary finatives will be employed. Two routine ones will be 1% OsO_4 buffered with collidine and acrolein-glutaraldehyde followed by 1% OsO_4 (Hyde, 1966). Embedding will be in an araldite epoxy-mixture and thin sections will be cut with a diamond knife on a LKB Ultramicrotome. Photographs will be taken on an RCA 3G electron microscope located at the University of Vermont Medical School, one block from the author's office and laboratory.

C. Significance of the Research

The nucleolus has been increasingly implicated in the synthesis (Wallace and Birnstiel, 1965) and/or assembly of cytoplasmic ribosomes. This generality accords with the long observed direct relationship between nucleolar size and cellular protein synthesis (Brachet, 1957). Since protein synthesis is an essential part of cellular development it is important to understand the nucleolus as well as possible.

Ultrastructural studies of the nucleolus (Lafontaine and Chouinard, 1963, and Marinozni, 1964) have shown it to be made up of several components. One is composed of ribosome-like particles, one is simply a mass of fibrils and a third is a smaller body not always attached to the nucleolus but having an ultrastructure differing only slightly from the fibrillar portion of the nucleolus. These components, which are ribonucleoprotein in nature, have been described as being embedded in an amorphous protein matrix. This study, then, will help to show which part or parts of the nucleolus are associated with its activity as a site for RNA and protein synthesis as well as, perhaps, a site for ribosomal assembly.

A second aspect of the nucleolus derives from the fact that it is organized by and functions directly in association with a particular segment of one or more particular pairs of chromosomes of the karyotype. The study thus goes beyond a description of the nucleolus and necessarily involves an understanding of the structural relationships between the nucleolus and the chromosomes.. Nucleolar function can be considered only a special case of chromosomal control of cellular activity. The information to be gained is of general significance to all biology -- theoretical, medical or agricultural -- because it will contribute to an understanding of nuclear control of cellular development.

D. Previous Work Done on this Project

The author has extensive knowledge and training on three makes of electron microscopes -- Philips, RCA and Siemens. He has been trained in the laboratories of Professors James Bonner and Alan Hodge at the California Institute of Technology and at the Cell Research Institute of the University of Texas under the direction of Professor W. G. Whaley. Publications dealing with problems mentioned in this proposal are listed below. This proposal is essentially an extension of the work done in the last year at the University of Texas.

Recent Work Done by Others on This Subject:

1963 Lafontaine, J. G. and Chouinard, L. A. A correlated light and electron microscope study of the nucleolar material during mitosis in Vicia fabs.

1964 Mariozzi, V. Cytochimic ultrastructurale de nucléole - RNA et proteince intra-nucleolaires. Jour. Ultrastructure Res. 10: 433-456.

1964 Schoefl, G. I. The effect of actinomycin D on the fine structure of the nucleolus. Jour. Ultra. Res. 10: 224-243.

1965 Wallace, H. and Dirnstiel, M. L. Ribosomal cistrons and the nucleolar organizer. Biochim. et Biophys. Acta. In press.

Work Done by Author on This Subject

1963 Differentiated chromosomes in Plantage ovata. Amer. Jour. Bot. 40: 809-813.

1963 Birnstiel, M. L. and Hyde, B.B. Protein synthesis by isolated pea nucleoli. Jour. Cell Biol. 18: 41.

1963 Birnstiel, M.L., Chipchase, M. F. H. and Hyde, B. B. The nucleolus, a source of ribosomes. Biochim, et Biophys. Acta. 76: 454-462.

1965 Ultrastructure in Chromatin. Prog. In Biophysics 15: 129-148.

1965 Hyde, B. B., Sankaranaryanan, K. and Birnstiel, M. L. Observations on fine structure in pea nucleoli, in situ and isolated. Jour. Ultrastructure Res. 12.

1965 Sankaranaryanan, K. and Hyde, B. B. Electron microscope studies of anuclear body with properties of both nucleoli and chromatin. Jour. Ultrastructure Res. 12.

1966 Changes in nucleolar untrastructure associated with differentiation in the Plantago ovata root tip. In preparation.

E. This budget is designed to provide the first essential equipment and help so that the writer may begin research at the University of Vermont. He is attempting in the small space available in the Hills Building to set up a laboratory for the preparation of biological material for electron microscopy. Experiment Station funds in the amount of $4,320 have already been committed to this project for three major items. This budget is to be spent entirely for a Kinney Vacuum Evaporator. This is an essential item in an electron microscope preparation laboratory because it is used for evaporating thin coatings of carbon or metal on biological specimens. The University of Vermont has also provided $5,000 to this project from an NSF supported institutional grant. The author is also preparing a proposal for additional Hatch funds and a major proposal to finance the purchase of an electron microscope to the NSF and NIH.

Amount of Grant Requested: $3,600

Personnel:

None

PROJECT XI

Title: Lehrman - Symanzik - Zimmermann Formula as a Calculational Technique in Field Theory

Investigator: Leonard M. Scarfone, Assistant Professor of Physics

Description of Research and Pertinent Background:

It has recently been shown by Maxon and Curtis[1] that the Lehrman-Symanzik-Zimmermann[2] (henceforth called LSZ) formalism can be used to calculate the quantities of interest in the first non-trivial sector of the Lee model.[3] It is well known that these are the elastic $N+_\theta$ scattering amplitude, the V-particle self-energy and the wave function renormalization constant. The solution of the $V\text{-}N_\theta$ sector is also obtainable with simple, straightforward eigenvalue equations[3] and with the methods of dispersion theory.[4,5] Using the latter technique, Amado[6] has extended the exactly solved part of the model to include both the $V+_\theta \rightarrow V+_\theta$ elastic scattering and the production process $V+_\theta \rightarrow N+2_\theta$. In addition to these transition amplitudes and renormalization constants, it has also been shown that dispersion methods[7] can be used to calculate two simultaneous algebraic equations for the vertex function $\langle V \mid f_N \mid B \rangle$ and $\langle N \mid f_V \mid B$ which yield an equation for the determination of the $V+N_\theta$ potential energy in agreement with that derived by direct methods.[8]

In this research, we are interested in demonstrating the usefulness of the LSZ function as a calculational technique. For this purpose, we first investigate the $VN\text{-}2N_\theta$ sector of a slightly modified LEE model and show that the LSZ approach solves the V+N problem and the $2N+_\theta$ scattering with one algebraic equation. The binding energy equation is obtained by studying the analytic structure of the V+N propagator and the scattering amplitude then follows.

We can also think of using the LSZ approach for the two V problem which is not exactly solvable with an eigenvalue equation and seems hopelessly complicated from the dispersion theory point of view The LSZ method should be especially helpful here since the symmetry properties of the χ-functions would be immediately obvious from the Matthew-Salam[11] equations as is the case with the $V\text{-}N_\theta$ and $VN\text{-}2N_\theta$ sectors. The two V problem is presently under investigation.

It is envisioned that the LSZ approach may also be used as a calculational tool in Quantum Electrodynamics. In particular, we hope to calculate with this method approximate expressions for the electron mass renormalization, charge renormalization and wave function renormalization constant. The problems here are conceptually clear and it is to be noted that this is a consequence of our experience with the Lee model. As an analogy, it is to be noted that DeCelles and Fieldman[9] calculated the V-particle self-energy and wave function renormalized constant with dispersion relation in the Lee model and then extended their consideration to Q.E.D.[12]

References:

1. M. Maxon and R. Curtis, Phys. Rev. 137B, 996 (1965).

2. H. Lehrmann, K. Symanzik and W. Zimmermann, Nuovo Cimento 1, 205 (1955).

3. T. D. Lee, Phys, Rev. 95, 1325 (1954). G. Kallen and W. Pauli, Kgl. Danske Viderskab. Selskat, Mat. Fys. Medd. 30, No. 7 (1955).

4. L. M. Goldberger and S. B. Treiman, Phys. Rev. 113, 1163 (1959)

5. P. DeCelles and G. Feldman, Nucl. Phys. 14, 517 (1959).

6. R. D. Amado, Phys. Rev. 122, 696 (1961).

7. L. M. Scarfone, Nucl. Phys. 39, 658 (1962).

8. S. Weinberg, Phys. Rev. 102, 285 (1955).

9. R. Ascoli and E. Minardi, Nuovo Cimento, 14, 1254 (1959).

10. The τ functions are vacuum expectation values of time-ordered products of Heisenberg operators.

11. P. T. Matthews and A. Salam, Proc. Roy. Soc. (London) A221, 128 (1953).

12. P. DeCelles, Phys. Rev. 121, 304 (1961).

Probable Duration:

It is anticipated that significant progress, leading to two or three publications, can be made on this research by 31 January, 1966. The actual appearance in print of papers can thus be expected during 1966 and early 1967.

Amount of Grant Requested: $4,285.

Personnel:

Principal Investigator: 10% of time - spring semester.
100% of time - two summer months
25% of time - fall semester.

PROJECT XII

Title: Calculational and Experimental Aspects of Entropy Determinations

Objectives:

The rapid proliferation of substances that can be considered "important" -- due to the efforts of the space program and the advances in biophysical chemistry -- requires a new approach to the tabulation of thermodynamic and thermochemical data. Twenty-five years ago most of the "important" compounds then known had been characterized experimentally. This is no longer true and will be an unrealistic expectation for the future. There is an obvious need for semi-theoretical and/or empirical methods of estimating thermodynamic quantities.

Heat capacity and entropy evaluations are useful in elucidating the microscopic structure of solids. They constitute a quantitative measure of molecular disorder. An entropy calculational program will be undertaken to correct previous assumptions used, to obtain rotational barriers; and to analyze phase transitions. In addition, the heat capacities of certain key compounds will be measured to test and refine the calculational methods.

Justification:

Until recently, the structure and behavior of solids has to a large extent remained a riddle. Thermodynamic studies are now assisting in defining the nature of this type of system. The materials used in the space program are subjected to bizarre conditions. Temperatures vary between very low and very high numbers. It is obviously of importance to have information on the properties of these substances or to be able to estimate their behavior by calculation. The latter approach is particularly pertinent since there is little hope of getting information rapidly from current experimental methods. Thus, this research will be directed primarily towards developing computational methods. Later, cryostats will be constructed to test and refine the results of the calculations.

Previous Work and Present Outlook:

One of the most important applications of low-temperature research to chemistry has been the use of heat-capacity measurements, and the concomitantly derived entropies, to determine the thermodynamic functions of chemical substances. The practical significance of heat-capacity measurements can be attested to by the fact that over half of the known free-energies of formation, used to calculate high-temperature equilibria, are based upon such studies. More recently low-temperature research

in chemical physics has become an important tool for elucidating the microscopic structure of solid materials. Heat capcity and entropy evaluations are particularly useful to this end because they give a quantitative measure of molecular disorder in crystalline systems; and because such data can be analysed to determine the nature of internal degrees of freedon that are not amenable to spectroscopy.

Currently the number of chemical substances that have been identified numbers in the millions. Twenty-five years ago it could have been said that most compounds of practical interest had been subjected to low-temperature studies. The rapid advances in space technology and in the life sciences are opening an ever widening gap between the number of compounds that are important and those that have been characterized thermodynamically. Every worker in the low-temperature field is awaiting the dawn of a new millennium in which heat capacity and entropy values can be calculated without recourse to difficult and expensive experimentation. This proposal deals with a two pronged attack towards that goal.

In 1864, Kopp deduced from the data then available that the heat-capacity of a compound is equal to the sum of the atomic heat capacities of its constituent atoms. (1) While, at best, an approximation this framework has become the basis for most subsequent calculational schemes. Latimer (2) and Janz (3) have given additivity schemes, for inorganic and organic materials respectively, that reproduce observed entropies to within several cal $mole^{-1}$ $deg.^{-1}$. Such schemes, since they are largely empirical, are in constant need of revision as more data becomes available. Latimer's values for transition metal compounds have been checked recently and are in great need of such revision. Turning to organic systems, the problem becomes more difficult. Several laboratories are engaged in thermodynamic studies to procure data for additivity relations. The problem is complicated because solid-solid phase transitions occur in many organic systems (about fifty percent of those studied), and because each single bond in the molecule leads to an internal rotation whose contribution is dependent on structure. Before such factors can be included in computational schemes, thorough analysis must be made of the existing data. This author has had experience in phase transition and barrier height problems (4).

On these bases, it is proposed that a calculational program be undertaken to (a) revise Latimer's additivity contributions, (b) continue the analysis of heat-capacity data to determine rotational barriers, and (c) to analyse phase transitions in terms of structure and symmetry. It is anticipated that such analyses will identify certain key compounds whose heat-capacity data will be needed to test and refine calculational results--hence, the necessity for a low-temperature laboratory.

The meaning of key compound, as described above, can be illustrated by considering co $(NH_3)_6Cl_3$. There are sufficient equilibrium and enthalpy data (5) to relate the entropies of ca. 50 species to that of $Co(HN_3)_6Cl_3$. Unfortunately we have nine paths for this latter quantitu that range from 61 to 112 cal $mole^{-1}deg.^{-1}$. The desireability of a definitive entropy value is obvious.

The biological function of many trace elements, such as Mn or V, is poorly understood, but is undoubtedly related to their ability to form complexes of varying stability in more than one oxidation state. If thermodynamics to become increasingly useful in biochemistry, we must begin with the simpler complexes and aqueous species involving these elements. The transition metals, which include most of the trace elements (and more important ones such as iron and copper), do not form reversible electrodes under normal conditions. Therefore other methods must be found to derive their partial molal entropies and free-energies. Third-law entropies, combined with solution calorimetry (6) form the clearest path to such data.

It is proposed therefore to measure the heat capacities of certain key compounds important to calculational schemes (e.g., $Co(NH_3)_6Cl_3$) to eventual biochemical thermodynamics.

References

1. H. Kopp, Ann. Chem. Pharm. Suppl.,3,1, 289 (1864)

2. W. H. Latimer, "Oxidation Potentials"; Prentice-Hall, Englewood-Cliffs, N. J., 2nd., 1952

3. G. J. Janz, "Estimation of Thermodynamic Properties of Organic Compounds", Academic Press, Inc., New York, 1958.

4. C. A. Wulff, J. Chem. Phys., 39, 1227 (1963) and C. A. Wulff and E. F. Westrum, Jr., J. Phys. Chem., 67, 2376 (1963)

5. For a discussion of transition metal thermodynamics, see L. G. Helper and C. A. Wulff, "Transition Metals: Oxidation Potentials, Aqueous Equilibria, and Thermochemistry" to be published in 1966.

6. C. A. Wulff has also applied for grants to study the solution thermochemistry of transition metal compounds.

Procedure

As indicated above, the initial effort in this research program will be devoted to the development and utilization of calculational methods for estimating entropies. A number of studies have been carried out in this area and calculations are now proceeding in the author's laboratory.

In the second phase of this project a low-temperature laboratory will be assembled. The major facility of a low-temperature laboratory is an adibatic cryostat, operating between 4 and 350° K. This author is familiar with several designs, and will build, with little modification, an apparatus similar to those designed by Professor Edgar F. Westrum of the University of Michigan. (Professor Westrum has kindly offered to make his shop drawings available.) Such research is expensive by calorimetric standards requiring a capital investment of $30,000 before any data can be produced. Construction, calibration and testing require between one and two years, with the help of a highly skilled mechanic and a well equipped shop. This time would, of course, be used for the calculational aspects of this program. Much of the capital investment is for components that are also adaptable to solution calorimetry. It is proposed that such components be purchased first. The following budget is for the first year, and anticipates continued support after that period from funds within and/or without the University of Vermont program.

Probable Duration

The total program described above is a long-range one. Results from the calculational portion of the work will begin to become available in publishable form in about six months. However, the construction of a low-temperature laboratory is a long-term project requiring one or two years before actual experimental operations are commenced. Thus, because of the nature of the program essentially continuous productivity can be anticipated almost from the time of inception.

Amount of Grant Requested: $13,248

Personnel:

Principal Investigator - 25% of time during academic year